Smart Energy and Smart Grids

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References

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1 From AMR systems to AMI systems

Adding more automation and bidirectional communication to the AMR systems we get *AMI* (**Advanced Meter Integration** or **Advanced Meter Infrastructure**) systems.

Such systems start to emerge around 2005. AMI allows real-time, **on-demand** integration with metering endpoints. Metering system **records consumption hourly or more frequently** (e.g. each 15 min) and that provides **daily or more frequent transmission** of measurements over a communication network to a central collection point.

The ultimate target of an AMI is [1] to have real-time energy data for utilities, consumers, and producers, to support their decision while considering the energy price as well.

AMI systems are part of the **Smart metering systems**.

AMI is perceived as an infrastructure that includes smart meters, communication networks, and meter data management Systems (MDMS) for data analysis and storage.

The smart metering systems are in EU specified by the Commission Recommendation 2012/148/EU, which defines 10 common minimum functionalities for smart metering systems:

a) For the customer:

1. Provide data readings directly to consumer and/or any 3rd party

2. Upgrade data readings frequently enough to use energy saving schemes

b) For the metering operator:

3. Allow remote data reading by the operator

4. Provide 2-way communication for maintenance and control

5. Allow frequent enough data readings for network planning

c) For commercial aspects of energy supply:

6. Support advanced tariff systems

7. Remote ON/OFF control of the supply AND/OR flow or power limitation

d) For security and data protection:

8. Provide secure data communications

9. Fraud prevention and detection

e) For distributed generation:

10. Provide import/export and reactive metering

2 What makes smart meter smart

The EU recommendations are transposed by individual governments and define more specific requirements for smart metering systems and from their end devices – **smart meters.**

Basic scheme and example picture of a smart meter is on Fig. 1. Visually there is not much to see except for display. When comparing to classical solid state / AMR meter, the core changes are inside.

Except for more demanding secure, bidirectional communication properties, there is significant shift to autonomous operation under varying condition, such as event management (meter logs and sends when predefined conditions are met), precise time management (time synchronization, time stamping of measured data), remote management capabilities (remote configuration, even software update), remote operation, such as tariff calendar update, disconnect/limiting.

Good example of smart features are events. There are four basic categories of events:

- **Meter status events**, such as “last gasp” (information about power failure), “first breath” (information about power restore). These notifications should be sent with randomization to

prevent communication congestion in case of mass events (or there is intelligence in the meter to differentiate between a mass power outage and individual power loss.

- **Power quality events**, such as voltage sag / swell (shorter duration of higher/lower voltage) and high/low voltage alarms (longer duration of higher/lower voltage). Here shorter means < 500ms , lower/higher means outside of the ±10% interval around nominal value.
- **Meter tamper flags**, such as reverse energy flow.
- **Meter hardware information**, such as battery alarms.

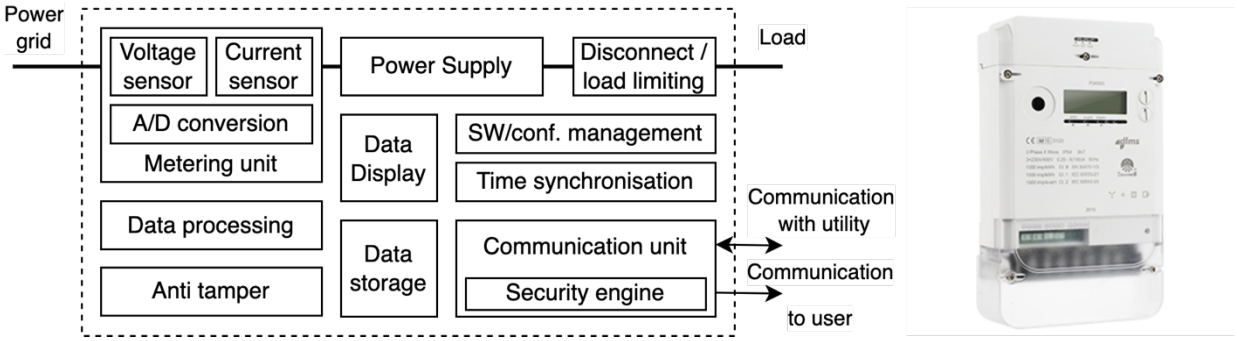

Fig. 1 Block scheme of a smart meter (left), example of realization (right)

3 Interfaces of smart meter

As stated in the Fig. 1, there are two types of communication – with DSO and to user.

Electricity Directive (EU) 2019/944 which formulates Functionalities of smart metering systems states that near real-time consumption data shall be available to final customers (users) through a **standardized interface to automated energy efficiency programs**, demand response and other services.

This important feature is also present in reference architecture for smart metering communications [2] developed by the **Smart Metering Coordination Group**, whose simplified version is depicted on Fig. 2. Here, the H1 interface connects the smart meter system to an external display. The H2, H3 interfaces connects the smart meter system with the Home Energy management / Home automation and provide a two-way communication. The connection is either using Local or neighboring Access point. Data from the smart meter is directly shared externally through AMI headend with to the Meter Data Management System (MDMS) via G1 interface. Or indirectly through C and G2 interface.

In [2] there is an overview of the preferred communication technologies for the different interfaces H1-H3, G1-G2 and C per country. For the G1, G2 prevails GSM based technology (sometimes closer specified as GPRS, 3G, 4G, LTE, NB-IoT). In the C interface **Power Line Communication** (*PLC*) prevails (the NNAP device servers as data concentrator in this case). The most varying are the preferences for the H interfaces.

The standardization as requested in directive 2019/944 is still far from EU wide unity. The obligation imposed in Directive 2009/72/EC is an 80 % roll-out of smart metering by 2020. Details about official deployment strategy per country is on Fig. 3.

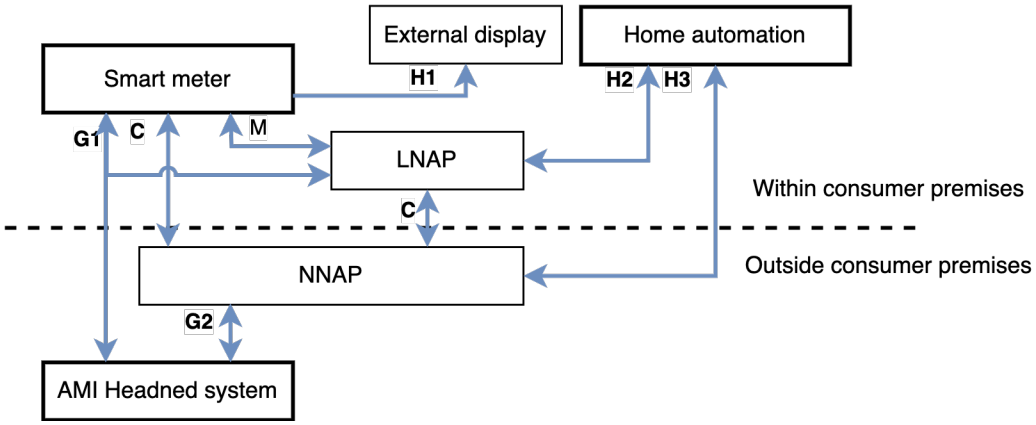

Fig. 2 Simplified and partial reference architecture for smart metering communications

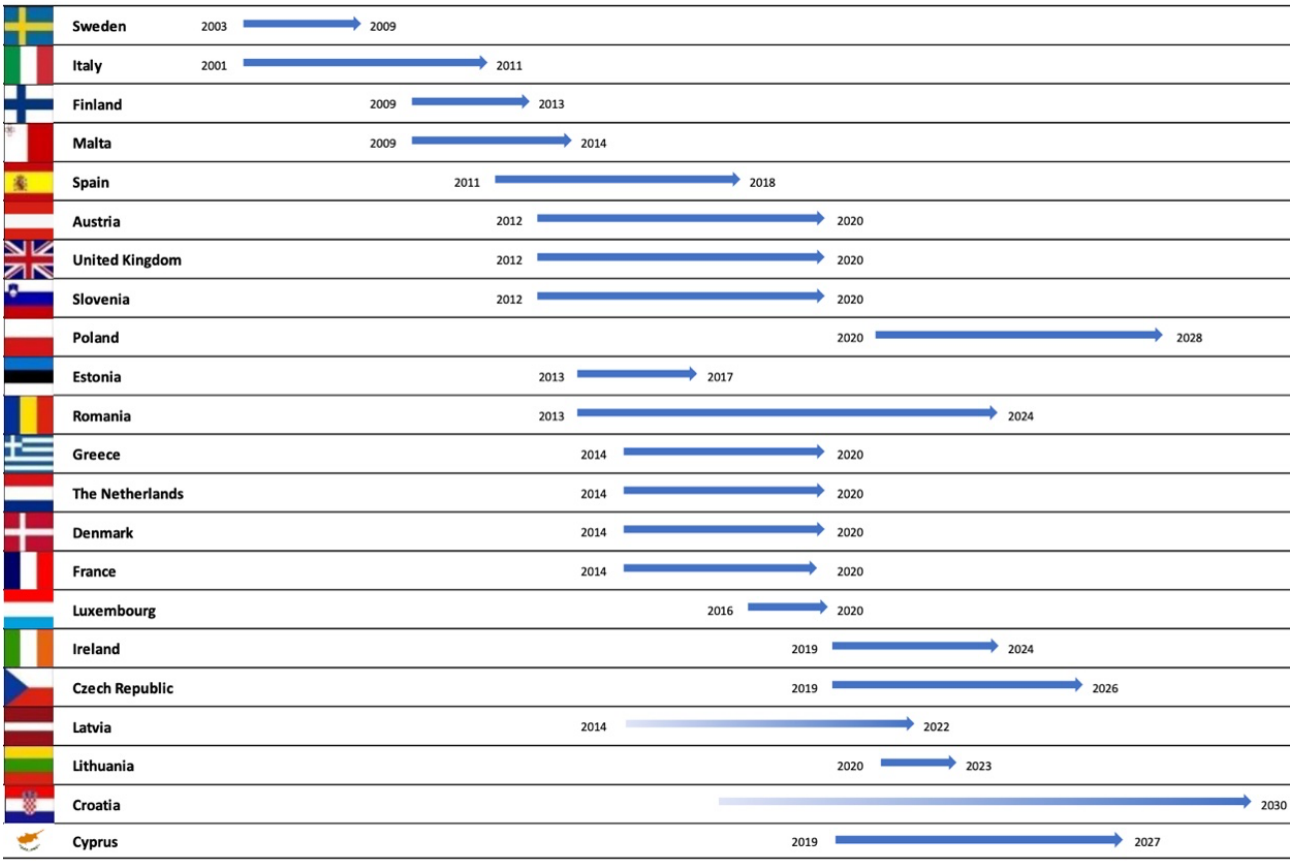

Fig. 3 Official smart metering deployment plan per country on the large-scale roll-out (80 % or higher coverage) of smart electricity meters [3]